# THE MECHANICAL DESIGN AND INSTRUMENTATION OF A FLOATING STABLE OCEANOGRAPHIC RESEARCH PLATFORM

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# THESIS

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OF A
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by

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September 1971

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# The Mechanical Design and Instrumentation of a Floating Stable Oceanographic Research Platform

by

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## ABSTRACT

The Naval Postgraduate School plans to erect a floating stable oceanographic research platform in 240 ft. of water in Monterey Bay during the spring of 1972. The platform will utilize a multi-point mooring system and will have a minimum of five tons reserve buoyancy and a total weight of 11 tons. The criteria for selecting an optimum location for the platform are discussed and a selection is made based on a compromise of the various considerations. It is concluded that the best source of power should be a submarine cable from the shore because of the five year minimum life expectancy of the platform. The initial set of permanently installed sensors should include instruments to measure basic parameters in the areas of Meteorology, Oceanography and Ocean Engineering. These include wind, air temperature, solar radiation, waves, tides, water temperature, salinity, currents, platform motion, platform tilt and cable tension. In order to provide a maximum variation of platform use, and to keep the weight of the platform a minimum, appurtenances including instrument booms above and below water, a rail and instrument cart system for profiling over depths, two working platforms and a 30 ft. instrument mast are described.

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# I. INTRODUCTION

The concept of using buoys to conduct oceanographic research is not new, but its popularity is increasing rapidly because the demand for more oceanographic and meteorological data and the prohibitive cost of survey ship operations have forced the evolution of instrumented buoys. These buoys can be manned, unmanned, moored, drifting, stable, unstable, large or small; the point being that there are as many different instrumented buoys as there are institutions that own them. Of particular interest to the Naval Postgraduate School is the "stable" buoy.

Stable instrument platforms are basically divided into three categories: bottom mounted, taut-wire moored and free floating. Each type has particular advantages and disadvantages as discussed below.

The University of Michigan uses a bottom mounted structure in Lake Michigan, as described in Ref. 1, where the mean water level is about seven and one half fathoms. This structure is very stable under most conditions in Lake Michigan making it a good platform from which to obtain data, however, the disadvantages to this type strucure are that it is restricted to one geographic location for the duration of its existence and the depth in which it may be placed. A more elaborate bottom mounted research platform in an ocean environment is located off the coast of San Diego where the U. S. Navy Electronics Laboratory has constructed an Oceanographic Research tower in ten fathoms of water. This structure is described in Ref. 2. The bottom mounted research platforms are limited to shallow waters primarily by the cost factors. Texas tower type structures in deeper water, like the U. S. Navy's ARGUS ISLAND, which was in 30 fathoms, are very useful to researchers, but it is difficult to justify the expense to build and maintain them.

The second category of stable platforms are taut wired moored buoys. These buoys achieve their stability by using the net buoyant force of the platform to act against the mooring cables. The buoyancy chamber remains submerged and thus acts as a constant force regardless of wave activity on the surface of the water.

The Bedford Institute of Oceanography, (BIO), Dartmouth, Nova Scotia, Canada, has deployed such a stable platform in water depths up to fifty fathoms using a spar buoy type structure and a nine point mooring system. The stability observed was well within the criteria set by researchers. This buoy has the capability of being recovered and redeployed as described in Ref. 3.

The third category of stable platforms is the long, thin free floating spar buoy, with high moments of inertia. The University of Oregon has developed the TOTEM series of buoys. These buoys, although moored, use the inertia of the structure as the primary stabilizing force. These structures, designed to operate in an open ocean environment, have achieved sufficient stability in this environment to make them useful platforms. The TOTEM buoy is described in Ref. 4. Another instrument platform that operates on this same principle is the U. S. Navy research vessel, FLIP.

All of the above buoys have long narrow bodies in order to maximize stability in roll and pitch and a minimum cross-section of the water line to minimize heave and surge forces.

In June 1970 the Naval Postgraduate School acquired a 90.5 ft. tower to convert into a FLOating Stable Oceanographic Research Platform, from here on referred to as FLOSORP. The tower originally was used as a THOR missile erector or umbilical tower. Due to its rugged design, the tower

is ideally suited for use in the ocean and therefore will be the basic frame, or skeleton, for the FLOSORP. As will become evident, the FLOSORP concept is very similar to the concept used by the Bedford Institute of Oceanography. The tower consists of two main sections. The lower section is a 60.5 ft. long steel frame with a square cross section that tapers from four feet per side at the base to three feet per side at the top. The upper section of the tower is a 30 ft. long aluminum frame with a square cross section, three feet per side. These structures are pictured in Figures 1 and 2. These two structures must be altered, preserved and deployed before the FLOSORP becomes a reality.

The FLOSORP is designed to sustain the environment in Monterey Bay for a minimum expected life of five years without maintenance other than periodic replacement of cathodic protection. The environmental design criteria, considered to be reasonable maximum expectations for Monterey Bay, are discussed below.

The maximum winds in Monterey Bay occur during winter storms with direction ranging between southwest and west. The winds from the northwest are rarely greater than 20 kts. The maximum recorded wind gust is in excess of 70 kts. for a storm in January of 1968. The one percentage risk winds for Monterey Bay are 40 kts. steady wind with gusts to 60 kts. for a five year period.

The largest waves recorded in Monterey Bay occured during a severe storm off the central California Coast on 9 February 1968. The wave height recorded in deep water was approximately 34 feet. This corresponds approximately to the "50 year wave."

There are no significant currents documented in the southern half of Monterey Bay along the 40f. curve. The maximum design criteria for the

Figure 1. Lower steel section of erector tower.

Figure 2. Upper aluminum section of erector tower.

FLOSORP and the mooring system are, a 21.3 foot wave, 30 kts. of steady wind and a 1.0 kt. steady current.

The establishment of an oceanographic research platform in Monterey Bay will be a significant increase in the capabilities of the Department of Environmental Sciences and the Naval Postgraduate School to conduct scientific research and to provide a facility where students can obtain data for thesis work as well as contribute significantly to Monterey Bay studies. The Naval Postgraduate School is scheduled to receive funds for the construction of an Ocean Science building and the permanent use of one of the Navy's Mini-AGORS. Both of these additions will help to bring this school into the forefront in ocean research, however, they will not be realized for several years. The recent acquisition of the research vessel ACANIA and the deployment of FLOSORP in the spring of 1972 will bridge the gap between the present facilities and those of the future.

The FLOSORP is intended to provide services to all members of the faculty and students who can use the special capabilities of the structure. As with most other research facilities, agreements can be made with other institutions for the utilization of the platform by non NPS personnel. The special capabilities mentioned above are the stationarity and the stability of FLOSORP. The platform provides the stability necessary for many types of investigations that cannot be undertaken from a research vessel. The continuous measurement of water parameters at a fixed location will serve as base line data for measurements in other parts of the bay.

The successful deployment of FLOSORP will serve as a model for future platforms of this type to be erected in other locations and in deeper

water. The ultimate goal is to establish a network of platforms from which data can be obtained simultaneously, then analyzed and correlated. This network of buoys will be useful as a reference in conjunction with data gathered by ships, aircraft or satellites.

In the design of buoys, a large number of requirements are placed on the designer by intended users all of which cannot simultaneously be satisfied. The overall objective of this paper is to consider the many requirements including oceanographic, meteorological and engineering and to provide a rational basis for decisions. The specific areas covered are: (a) to propose suitable locations in Monterey Bay where the FLOSORP can be placed and also best meet the requirements set by scientific needs, boat accessibility, telemitry and power systems, and governmental agencies. (b) to propose and describe the appurtenances to be mounted on, and the design of the structure to make the buoy a useful research platform. (c) to consider and describe an electronic suit for the platform, (d) to consider the various parameters to be measured and to propose a sensor suit for the FLOSORP and (e) to consider the effects of buoy motion on the sensor accuracies.

## II. PLATFORM LOCATION

In the process of determining an optimum location for the proposed platform, the author used the following two considerations as basic constraints. The first limits the depth of the water in which the platform can be placed at 240 ft. and the second one requires the bottom to be relatively flat. Both of these restraints are primarily associated with the mooring system for the platform. Neither requirement has to be met precisely, but any deviation from them should be small and must be supported by a genuine need to do so.

The factors which are considered in determining the best location for the platform are discussed individually. The reader, however, must realize that all factors are interrelated. Although not all of the factors involved in these relations are discussed, the more important ones are presented here to serve as a guide for future decision makers in matters of this nature.

By examining the chart of Monterey Bay, Figure 3, one can immediately discern two areas within the forty fathom curve where a platform site would be prohibited. These are the NAVAL OPERATING AREA 204.205 in the northern portion of the bay and the combination RESTRICTED AREA 204.205 and PROHIBITED AREA 204.205 in the southern half of the bay. In the NAVAL OPERATING AREA a scientific structure would interfere with periodic Navy minesweeping exercises and in the PROHIBITED and RESTRICTED AREA, the scientific platform could be accidentally hit by a projectile from the FORT ORD firing lines. The remaining portions of the bay on the forty fathom curve are available for possible sites. These can be divided into three general areas; north of the FORT ORD firing areas, south of the

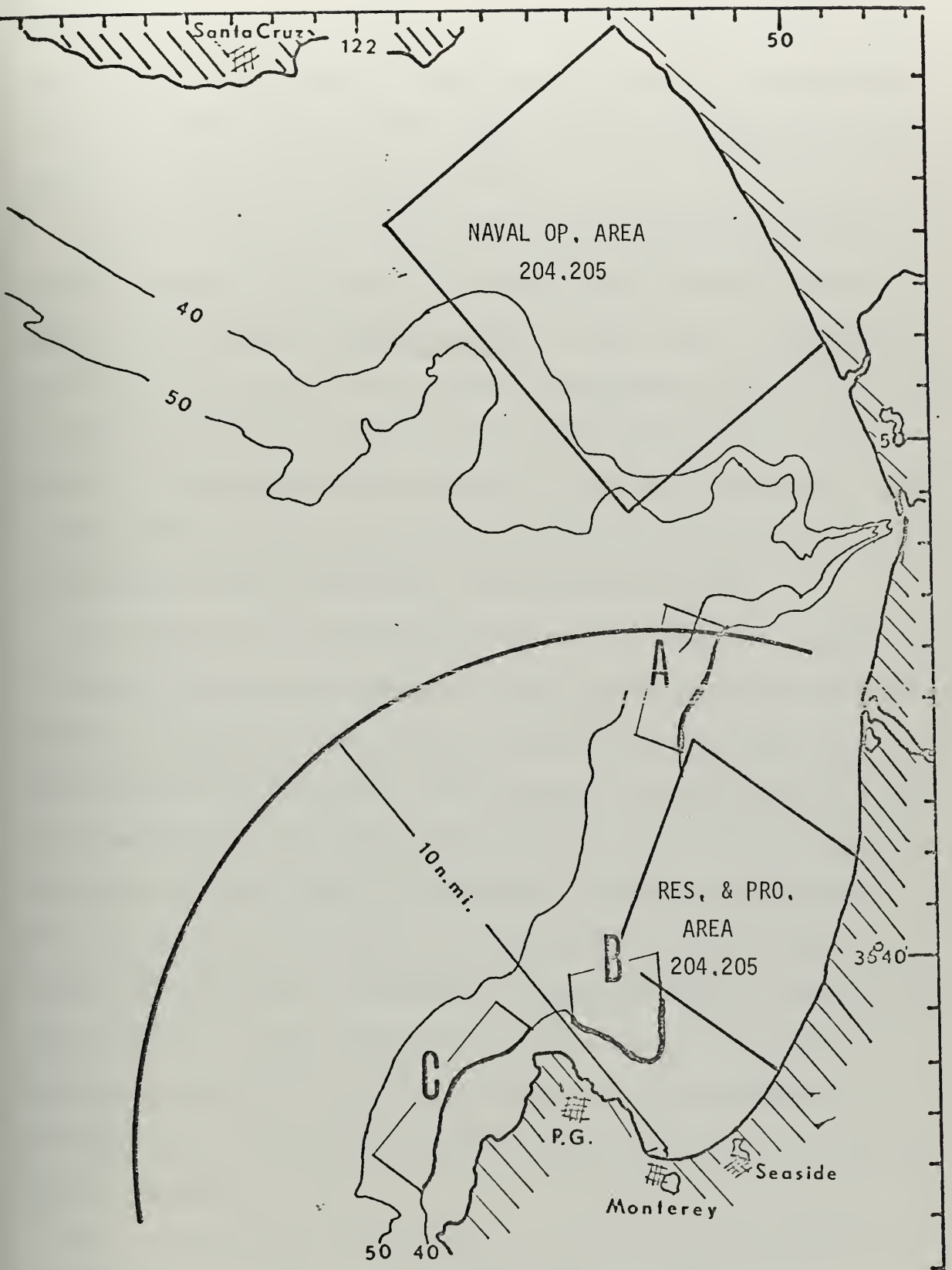


Figure 3. Copy of C.G.S. Map 5402 showing the government controlled areas, the ten nautical mile limitation, and the areas of interest, A, B, and C.

FORT ORD firing area and the area seaward of POINT PINOS. These areas are indicated by A, B, and C respectively on Figure 3. The area to the west of the NAVAL OPERATING AREA, near Santa Cruz, is considered to be too far for the initial platform location.

The first factor to be considered is boat accessibility. This concept includes time to reach the platform from the harbor and the limits on the sea state to make a transfer from a boat to the platform feasible. It is assumed that the Naval Postgraduate School will continue to retain a utility boat such as the "40 foot launch" for the primary purpose of ferrying people and equipment to and from the platform. Boats of this nature are used by the navy for such transfers to ships at anchor and should be readily available to the Postgraduate School.

The platform must be within ten nautical miles from the entrance of Monterey Harbor as indicated on Figure 3. Since only day use of the FLOSORP is planned, no provision for staying overnight, except on an emergency basis, will be made. This distance is the maximum that a boat could traverse in a reasonable interval of time and still allow adequate research time. For example: assuming that the boat can make good 7 knots over land, then it will take roughly one and one half hours to traverse this distance. A researcher, planning to conduct research from the platform, must spend three hours total in the boat. As indicated, this ten nautical mile limit is a maximum; a shorter ride would be preferable, but the author believes that adequate time remains from the day for research.

The question of sea state limitations for boat transfer operations can only be answered in a broad sense in this paper. The ultimate decision as to whether the transfer is safe must be made by those individuals who are actually involved; however, as a guide, the maximum wave height in

which transfers should be undertaken is five feet. The FLOSORP is like an exposed pier for boat transfer consideration because of the absence of heave motion. A boat approaching the platform will have a significant vertical relative motion with respect to the platform. It is of interest, therefore, to find which of the possible platform locations has the most suitable sea conditions to give a maximum opportunity to conduct boat transfer operations.

The predominant seas and swell affecting Monterey Bay are summarized in Ref. 5, and depicted in Figure 4. The majority of wave action is from the southwest to northwest quadrant and areas A, B and C in Figure 3 are all subjected essentially to the same wave environment. Waves at A and B will be less than C which is essentially on the open coast. Figure 5 shows wave refraction diagrams for a 12 second period wave which is about the average period of swell incident to Monterey Bay. The areas inside the Bay are in an area of wave divergence for all wave periods and will be less than the open coast location of C. Although, the actual variation of the average sea state between the locations is small, for boat operation purposes, the best location for the FLOSORP is in area B due to the time in transit differences.

The second factor considered is a line of sight requirement that a telemetry system on the platform would have with the present Oceanographic Beach Lab., Building Number 514. This requirement eliminates all sites seaward of Point Pinos, indicated by area C in Figure 3.

The third factor is the special requirement that the power cable for the platform imposes on platform location. The platform will be powered by submarine cable from the shore. Cost considerations alone dictate that the cable to the platform be as short as possible and that it be

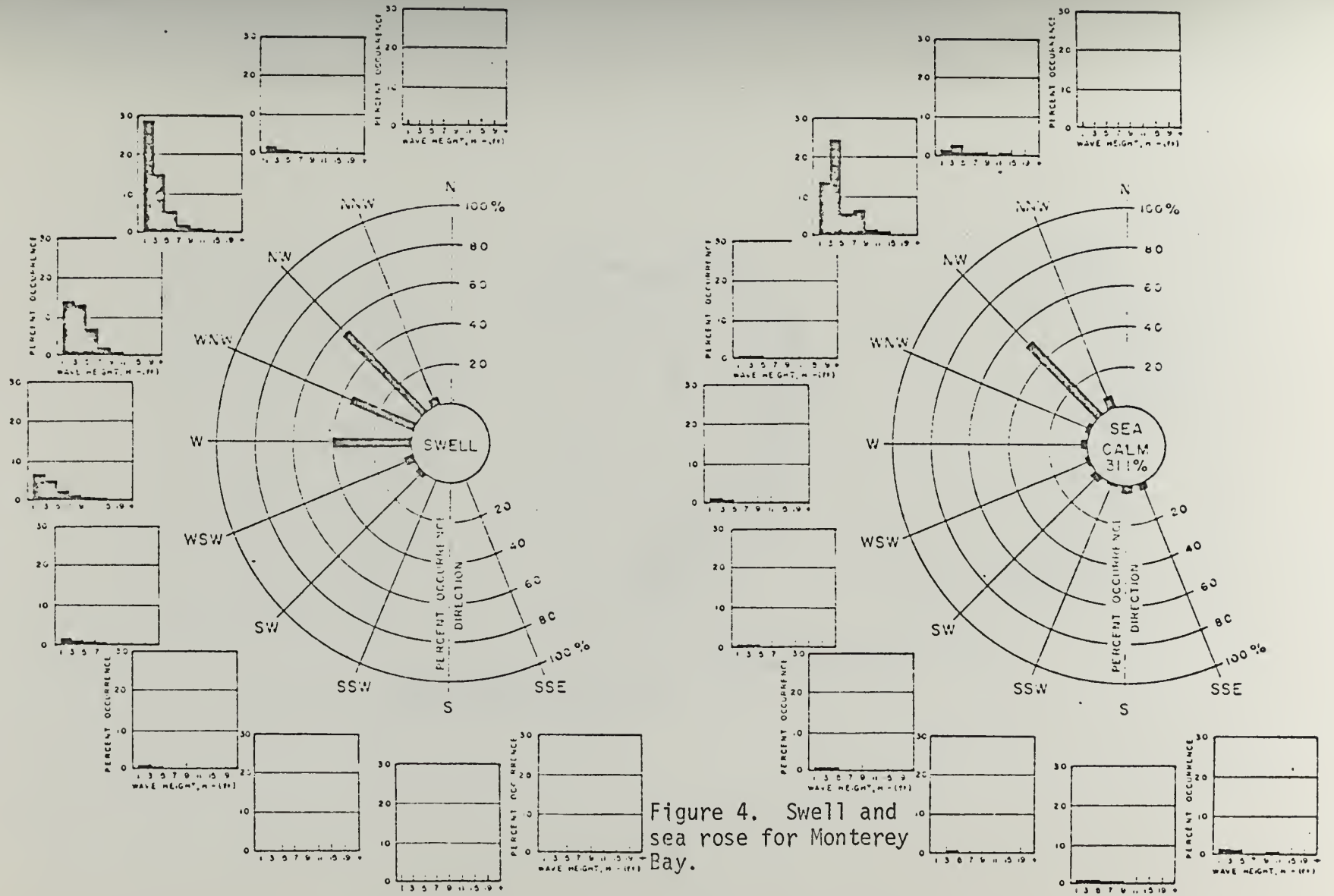


Figure 4. Swell and sea rose for Monterey Bay.

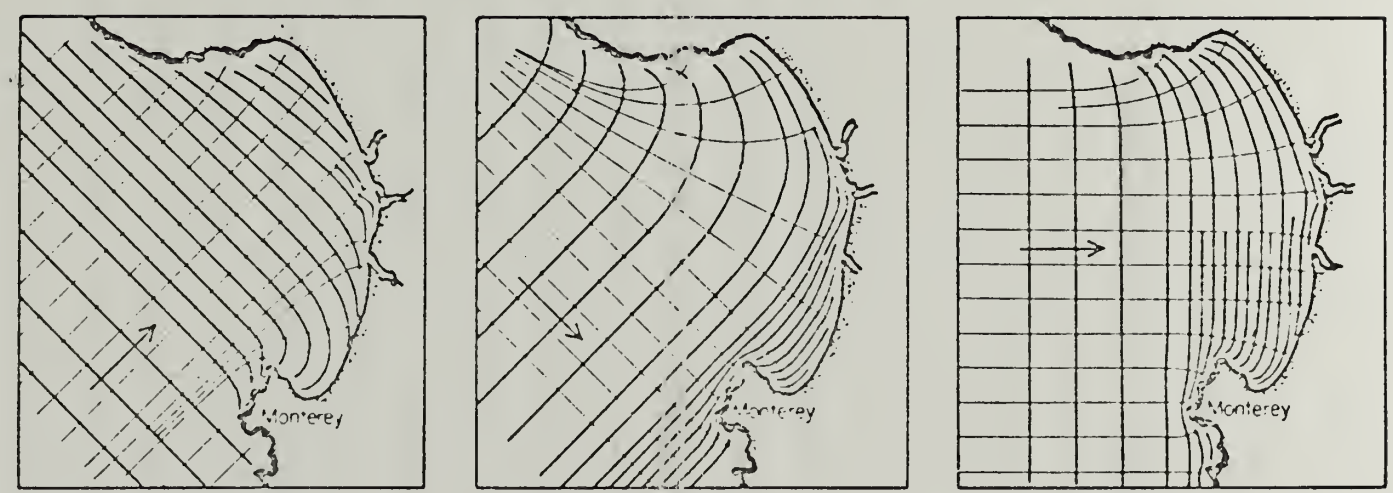


Figure 5. Selected wave refraction diagrams for Monterey Bay. (After Wiegel, Ref. 6)

passed through the surf zone where the least amount of cable protection is required. A second consideration is power transmission requirements. A longer cable requires higher transmission voltages, and thus requiring higher rated cables at a higher price. Both of these considerations can be best met at the southern most part of the bay at Del Monte Beach with FLOSORP location in Area B. From the intensity of swell inferred from Figure 5, this area is definitely the most favorable one. The rocky shore northwest of the harbor would make cable laying too expensive because of the extensive armouring that the cable would require and too risky in terms of cable reliability. The point of water entry for the cable must be north of the proposed breakwater for Monterey harbor.

The fourth consideration is the requirement to place the platform in a relatively remote location where there is the least likelihood of unintentional interference with platform operations by fishing or pleasure boats. Area B in Figure 3 is usually quite active, especially on weekends. The existing buoys marking the PROHIBITED AREA are favorite marks for sailboat races. Area A is much more remote than area B and would therefore be a better location for the platform.

The fifth factor is one of aesthetic nature, but perhaps is one which in the end will prove to be the most important. If ignored, it can jeopardize local approval for the oceanographic research platform project. The platform must not be placed in such a location where it would obstruct the natural beauty of the California Coast. A structure, extending sixty-five feet above the water, painted a bright orange color and only two miles off shore, would not be appreciated by those individuals that come to the shore to enjoy a sunset on the Pacific horizon. A platform placed in area A, however, would not spoil the view of many,

if any, people because of the unaccessibility of that portion of the coast. A logical choice for platform location from this consideration is area A.

The last and primary factor which must be considered when selecting the optimum location for a platform of this nature, is one of scientific need. What will be of primary interest to researchers working with data from FLOSORP? What are the requirements for the affects of nearby land or boat activity? Since the sea and swell are not significantly different between areas A, B and C, platform stability versus location will be nearly constant. The type of data, however, will not be the same. Many studies of Monterey Bay circulation have shown that the southern most portion of the bay, including area B, is relatively stagnant. To get data indicative of bay circulation, or flushing, the FLOSORP must be located in area A, since area C is not in the bay. Those researchers desiring maximum stability of FLOSORP would favor the most protected or sheltered location in the bay. By requiring this stability, however, the parameters of interest could be prejudiced by nearby land or bottom effects. Other researchers, those interested in wave studies for example, can compensate for platform motion and thus favor a location where the least land and bottom influences are present. A compromise must be made and there will be types of studies for which the platform will be unsuitable. Because of the five year life expectancy of the platform, it would be unwise to select a platform location based primarily on the studies of a few parameters of current interest. A more general criteria of maximum flexibility in significant parameters available for study is warranted. From these considerations, areas A and C would be suitable for platform location.

To summarize this section, the following requirements have to be satisfied by the platform location. The FLOSORP must be within 10 n. mi. of the Monterey harbor, and it must be within the line of sight of the Beach Lab area. It is preferable that the proximity of FLOSORP to shore be in an environmentally dynamic part of the bay and where it does not attract the attention of people from shore or in small boats. With these constraints in mind, the author recommends the following primary and alternate location for the FLOSORP. The primary location for FLOSORP should be at 36°43,95'N and 121°52.65'W, the intersection of the seaward and northern edges of RESTRICTED AREA 204.205 and the 40 fathom curve. This point is 7.5 n. mi. from the U. S. Coast Guard breakwater and is 3.25 n. mi. from the nearest point of land. It is in the active part of the bay and satisfies the line-of-sight requirement. The alternate location is at 36°39.60'N and 121°53.5'W, the intersection of the southern edge of RESTRICTED AREA 204.205 and the 40 fathom curve. This point is three nautical miles from the U. S. Coast Guard breakwater and 2.1 n. mi. from the nearest point of land. Although this point is closer to the harbor, it is readily visible from the populated areas of Monterey and Pacific Grove and it is in an area of much boat activity. From a scientific viewpoint it is not as desirable as the primary choice.

## III. PLATFORM APPURTENANCES

To make the FLOSORP a flexible yet uncomplicated facility to use, several additions must be made to the basic floating structure. These appurtenances are to be attached after the floatation has been incorporated into the erector tower, but before the platform has been deployed. A complete description of these fixtures is presented in this section, however, the illustrations are not intended to serve as drawings for manufacturing the devices. Sufficient information for making a drawing is given. A general concept of operation of FLOSORP is shown in Figure 6.

### A. UNDERWATER BOOMS

One 17 ft. boom will be attached at the base of the platform. Its primary function will be to act as a support for blocks associated with a pully system attached to the instrument boom at the main platform. The underwater boom can also serve as a support for sensor arrays suspended below the platform. These sensors can be varied as desired by individual researchers, but they must be fastened to a boom to prevent fouling with the anchor cables. A brace to stabilize the boom will be attached to the boom as shown in Figure 7. The boom will be constructed from four inch thick wall pipe and the braces from two inch thick wall pipe.

One boom, extending 10 ft. out and 5 ft. down from the base of the structure, will be mounted to the base of the platform on the opposite side from the 17 ft. boom. The boom will be braced as indicated in Figure 8. The boom and brace will be constructed from two-inch, thick walled steel pipe. The primary purpose for this boom is to support the permanently mounted thermistor chain, salinometer and current meter.

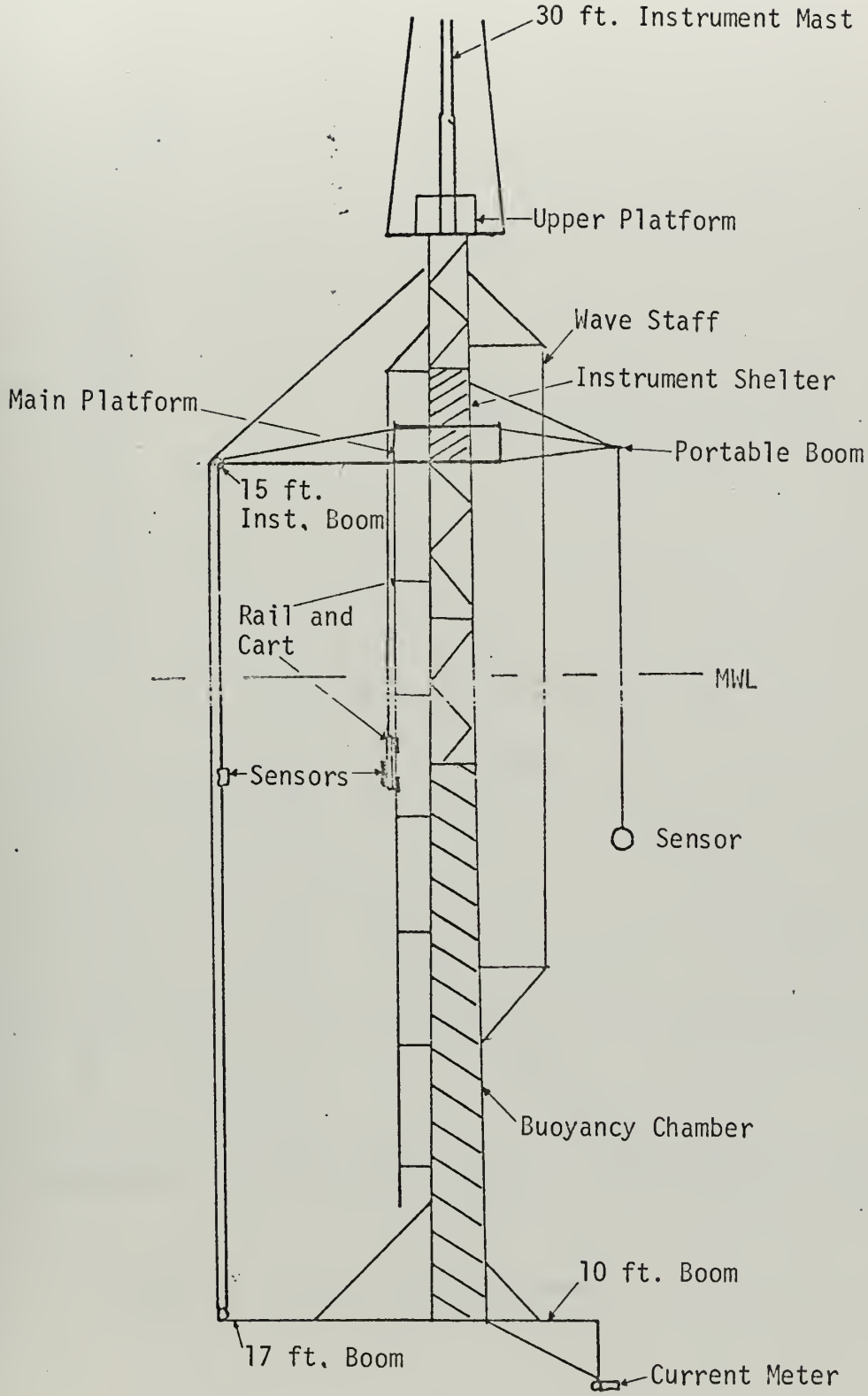


Figure 6. A General Concept of Operations
(The relative position of the various appurtenances is not in true perspective.)

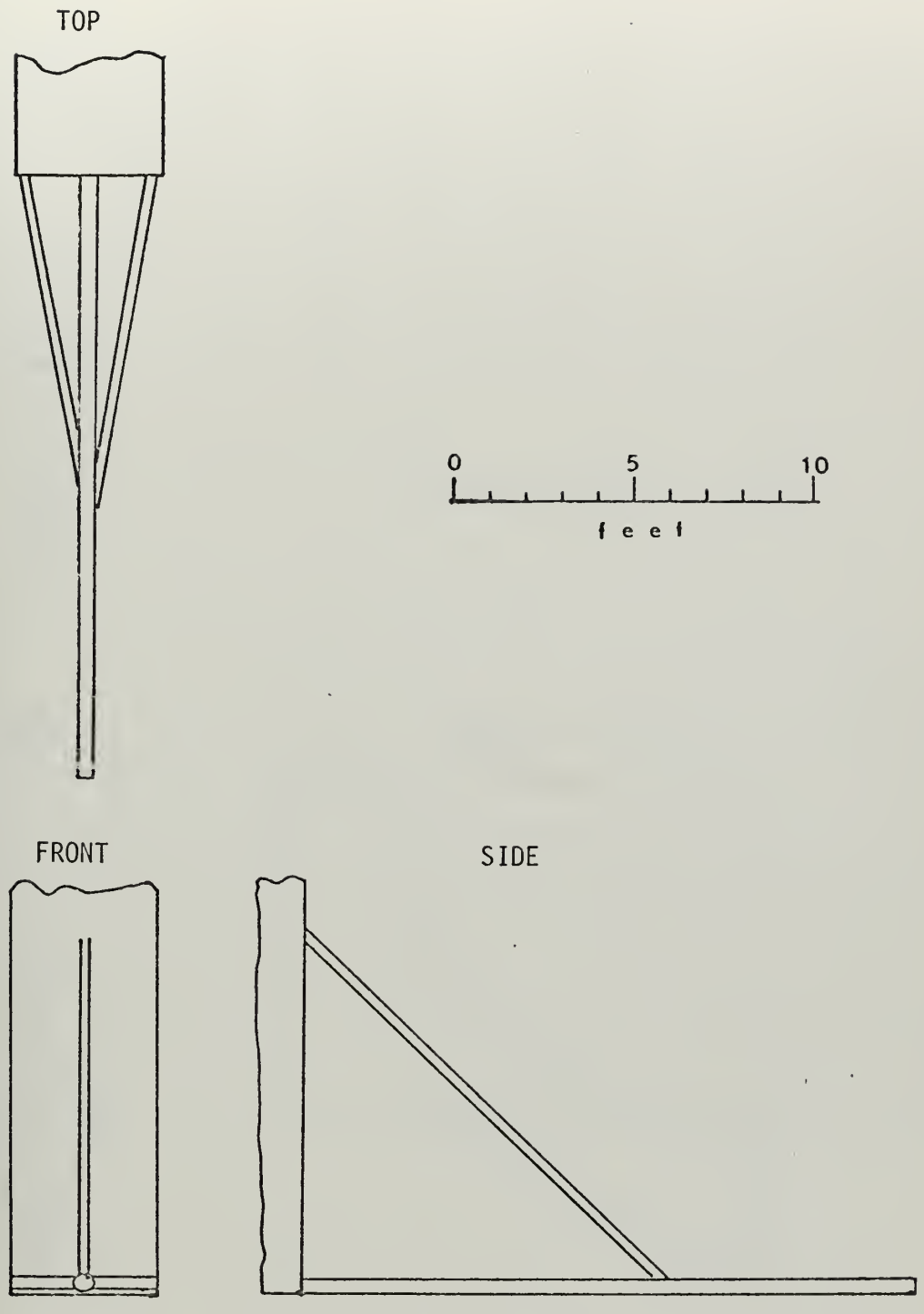


Figure 7. 17 ft. Underwater Boom

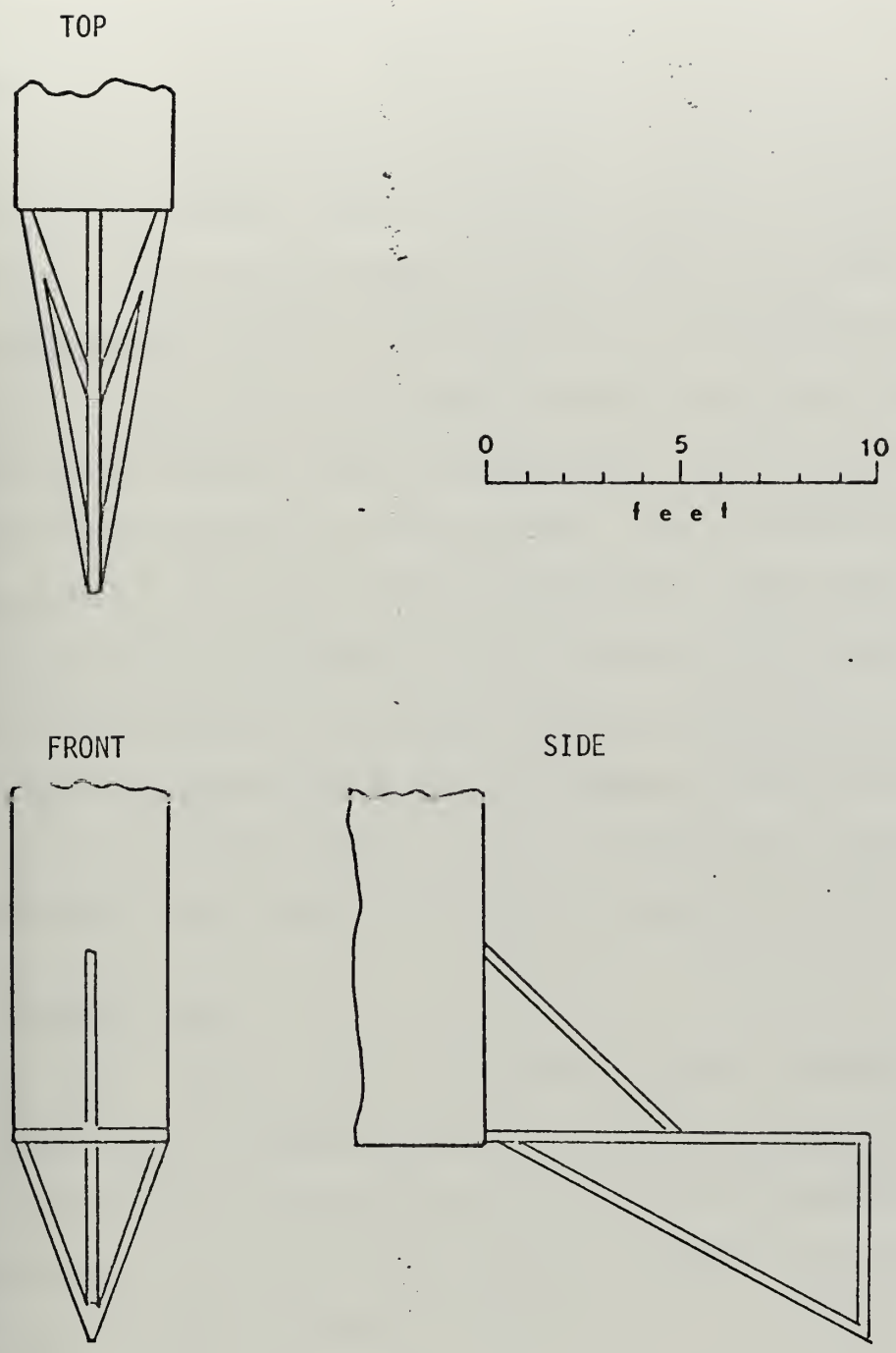


Figure 8. 10 ft. Underwater Boom

B. LADDER

A ladder will be attached to the structure extending from the base of the FLOSORP to the lower platform as shown in Figure 9. The purpose of the ladder is to aid divers when they are working on the FLOSORP at varying depths. Sensors, cages containing organisms or wooden boards for fouling studies can be attached to the FLOSORP at any desired depth on a semi-permanent basis. The ladder will be constructed from two materials. The portion of the ladder attached to the steel frame will be constructed from two inch steel angle iron. Steel braces will be attached every ten feet for ladder support. The remaining portion of the ladder will be constructed from two inch aluminum angle stock.

The ladder will be attached at the landward side of the FLOSORP. This side of the FLOSORP will offer some protection from waves for divers who must climb the ladder through the sea surface. Placing the ladder on this side will also alleviate the necessity of constructing a separate ladder for the boat landing since this ladder can also fulfill that requirement.

C. INSTRUMENT RAIL

One rail, located on one of the seaward sides of FLOSORP will give the capability of a stable mounting for lowering instruments to a precise depth from the main working platform. The rail will extend from the main platform down to ten feet above the base of FLOSORP with a support every ten feet, as shown in Figure 10.

The rail will be constructed from two, one-inch, thick walled aluminum pipes joined by an 18 inch aluminum spacer bar at the same places where the main braces support the rail, as shown in Figure 11. The rail will extend approximately three feet out from the main structure. This

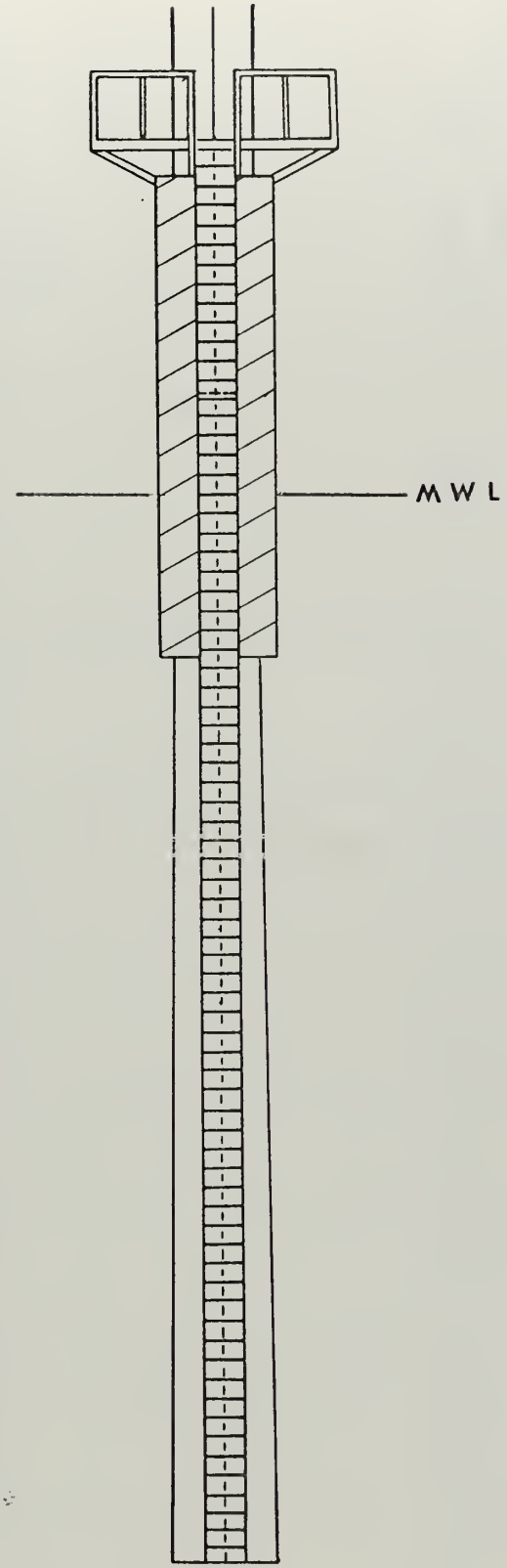


Figure 9. Ladder and boat fender.

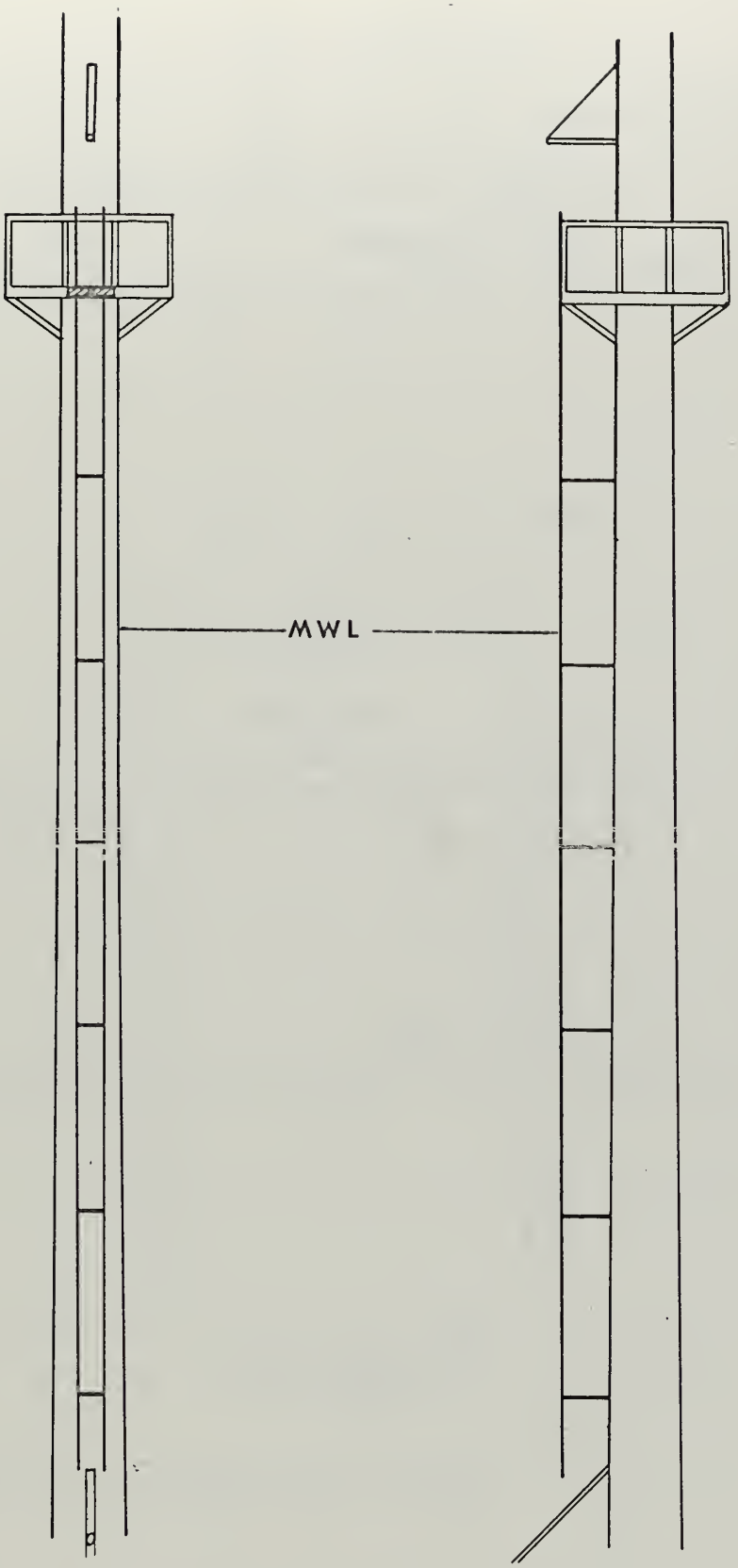


Figure 10. Instrument rail showing front and side views.

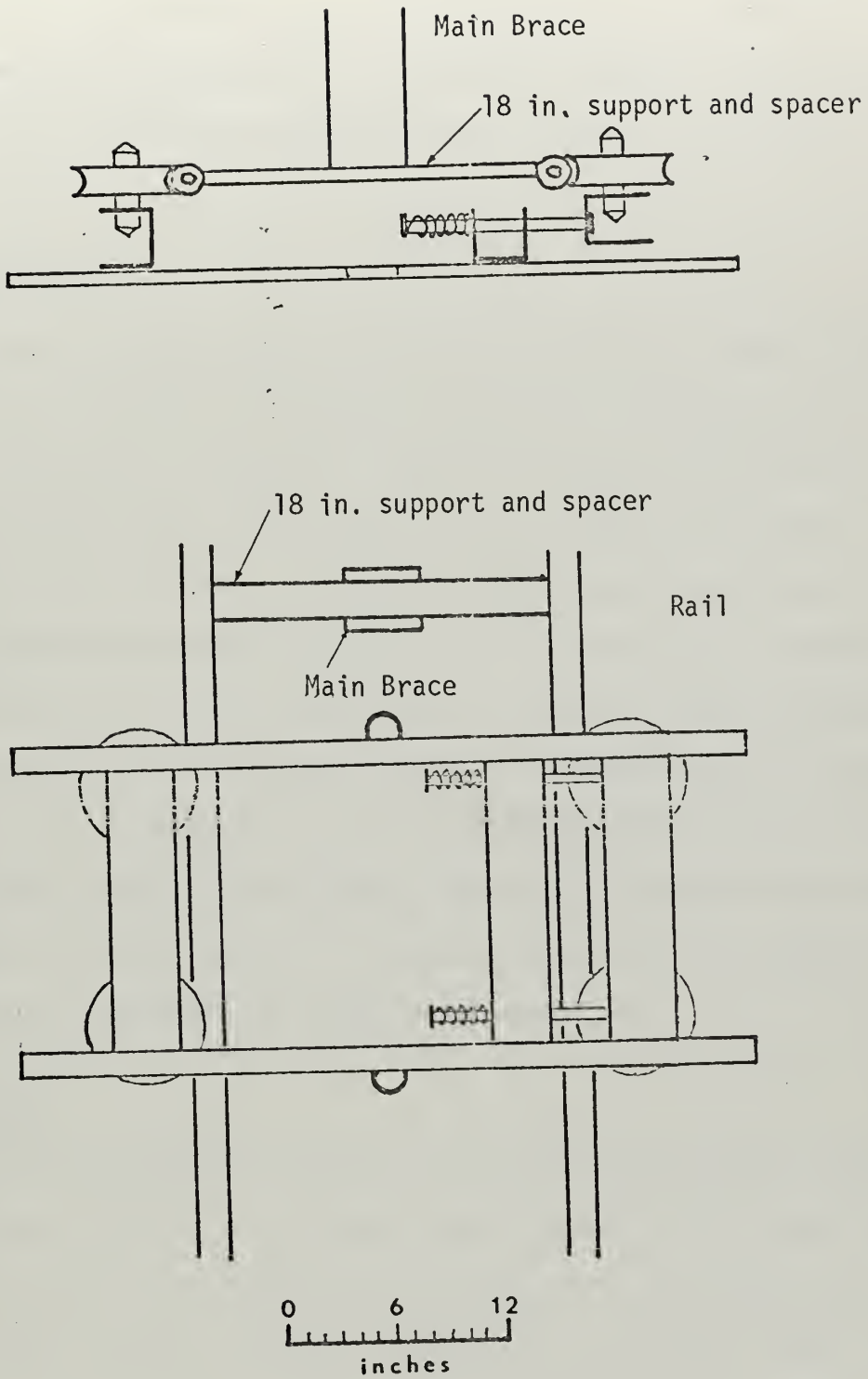


Figure 11. Instrument Cart and Rail

configuration gives optimum access to the rail at the main platform as well as a minimum of interference from the main structure. The instrument cart wheels will ride on the outboard side of the pipes. The cart is described next.

## D. INSTRUMENT CART

The proposed instrument cart is of a simple design to insure optimum reliability and flexibility. The cart consists of a carriage and four wheels as illustrated in Figure 11. The cart is placed on the track by sliding it onto the track at the upper end. The right set of wheels is forced against the track by a spring mechanism to stabilize the cart. The spring tension can be set to adjust for load variations. The cart will travel down the track from the force of gravity. A cable attached to the cart will be used to retrieve the cart and payload and to control the cart travel. A strong back, eight feet above the platform, will be used to suspend a manual winch system, which will be used to control the lowering and raising of the cart. A metering wheel will be attached to the strong back to indicate the distance of travel.

## E. BOAT FENDER

A boat fender, capable of absorbing relatively large shocks, must be provided on the FLOSORP. The maximum expected change in the water depth due to tide levels is ten feet at the platform site. The maximum wave height for boat transfers with the platform will be five feet; thus the total span of the sea surface variation will be about 15 ft. Allowing four feet for the boat freeboard and a minimum of three feet as a safety margin at both ends of the fender will make the minimum length of the boat fender twenty five feet. The boat fender will be mounted at the

mean water level, but displaced four feet toward the upper end to compensate for the boat freeboard.

The boat fender construction will be as illustrated in Figures 12 and 13. Weight considerations require that aluminum be used vice steel for the fender supports. The number of braces, however, is sufficient to withstand any reasonable shock from a boat. The two main shock absorbers will be made from treated hardwood and will be supported by 14 braces each. The braces will be constructed from two-inch thick walled aluminum pipe. The ladder will be reinforced where it is used to join the two main fenders.

F. LOWER PLATFORM

The lower, or main platform, 18 ft. above mean sea level, is the primary working space of FLOSORP. It is a 9 by 9 foot platform constructed from 3.5 inch aluminum I-beam frame with an expanded metal floor. The handrails will be 3.5 ft. above the platform floor. All rails and stanchions will be made from 2 inch aluminum pipe. All auxiliary equipment will be controlled from this platform. The main fixtures on the platform are described below.

1. 15 Foot Instrument Boom

One 15 ft. instrument boom will be mounted at one of the seaward sides of the platform directly above the underwater boom. The boom will be constructed from two-inch thick walled aluminum pipe. The two main sections of the boom are attached to the platform with three foot separations and centered about the rail as indicated in Figure 14. The boom will be supported by a wire led through a block at the top of the main structure, and then secured on the lower platform level.

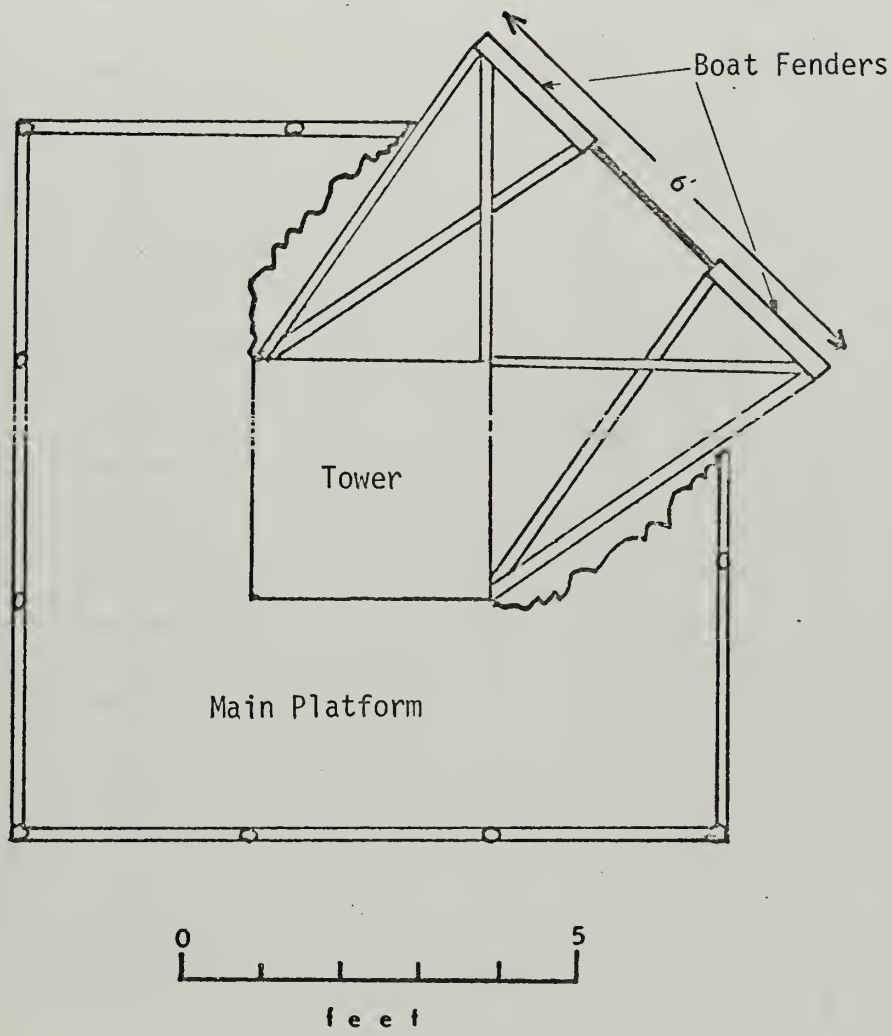


Figure 12. Top view of boat fender.

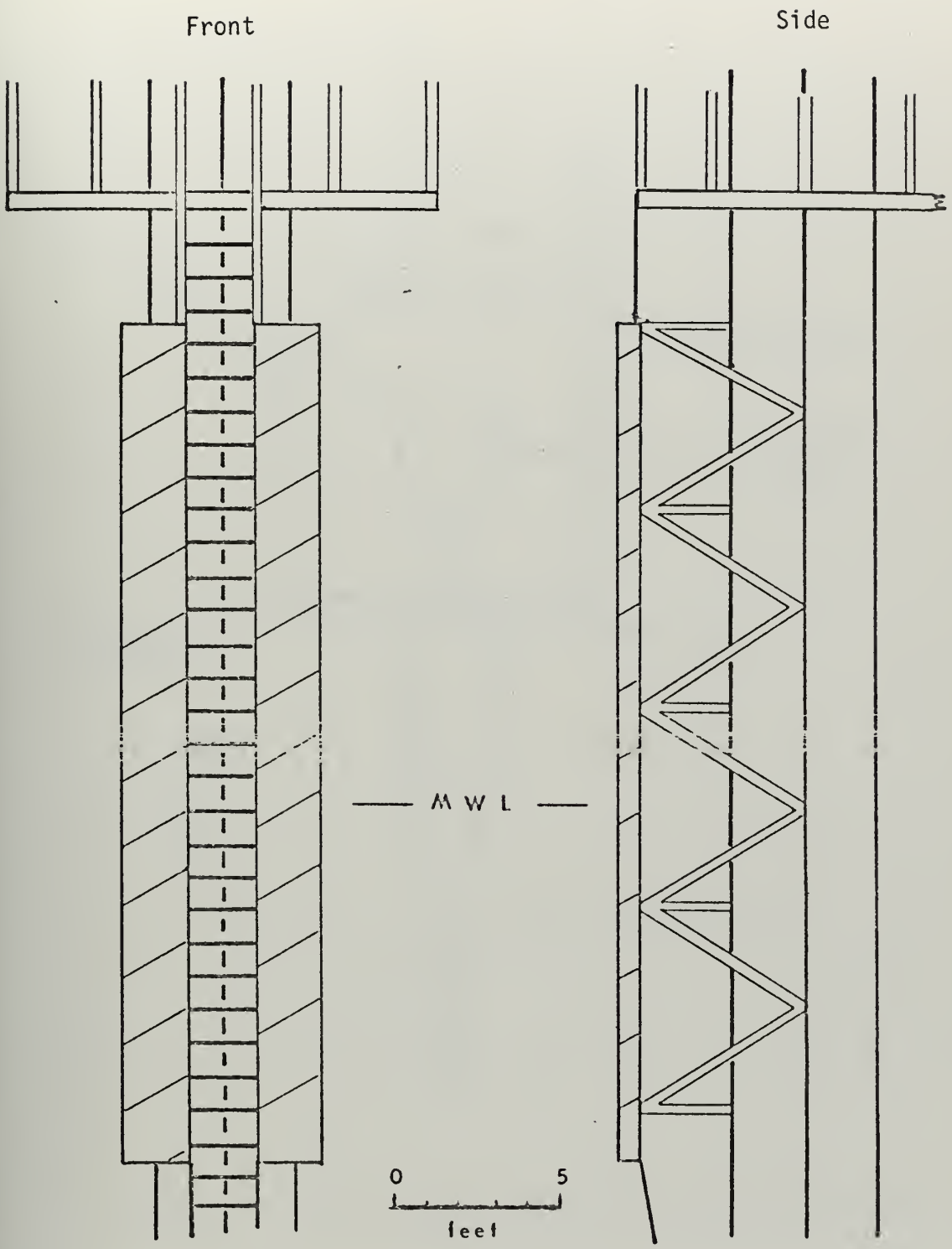


Figure 13. Side and front views of boat fender.

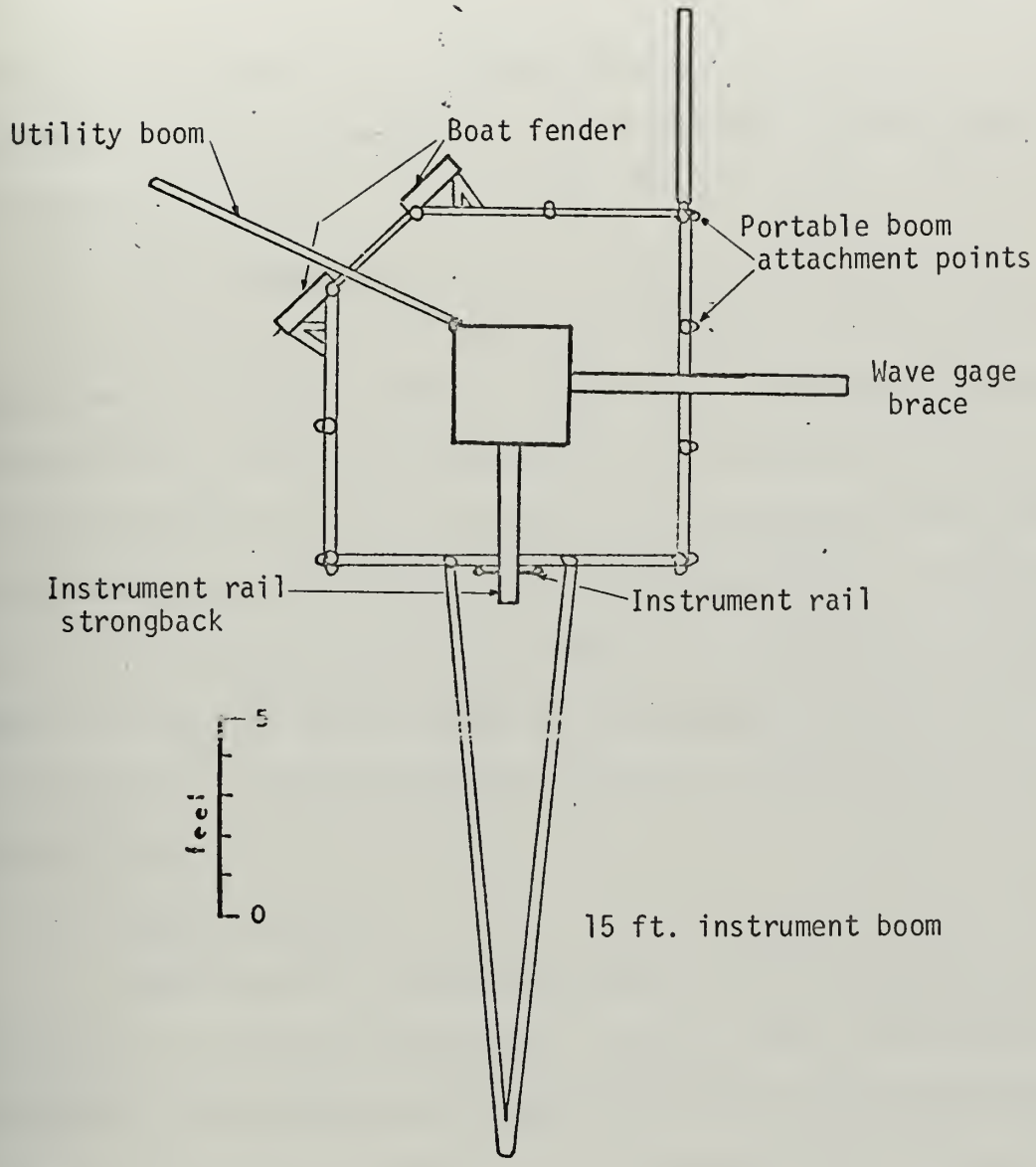


Figure 14. Lower platform showing the associated fixtures.

2. Instrument Cart Strongback

Eight feet above the platform deck and directly over the rail, a strongback will be attached to the main structure. The strongback will be constructed from 3.5 inch aluminum I-beam stock as shown in Figure 15. Attached to the strongback will be the blocks and metering wheels for the instrument cart cable.

3. Utility Boom

A ten foot utility boom will be mounted on the main structure above the boat fender as shown in Figure 14. The boom will be constructed from two inch thick walled aluminum pipe. The boom can be utilized for lifting equipment in and out of the boat, for passing equipment down to divers working on the ladder below, to make hydrocasts or to make mechanical bathythermograph casts. The boom will be supported by a block and tackle attached to the main structure and the outboard end of the boom to facilitate raising and lowering the boom. The wire will be controlled by an electric winch.

4. Wave Gage Brace

Two braces for a 50 foot Wave Staff will be mounted on the main structures at the following points: at 28 ft. above mean water level and at 25.5 ft. below mean water level at one seaward side of the FLOSORP as shown in Figure 6. The braces will be constructed as in Figure 15. The upper brace will be made from 3.5 in. aluminum I-beam extending 7 feet out from the main structure. The lower brace will be constructed from 4 in. steel I-beam.

5. Boom Attachments

To provide additional stations from which to erect booms, proper fittings must be welded in place prior to the deployment of FLOSORP.

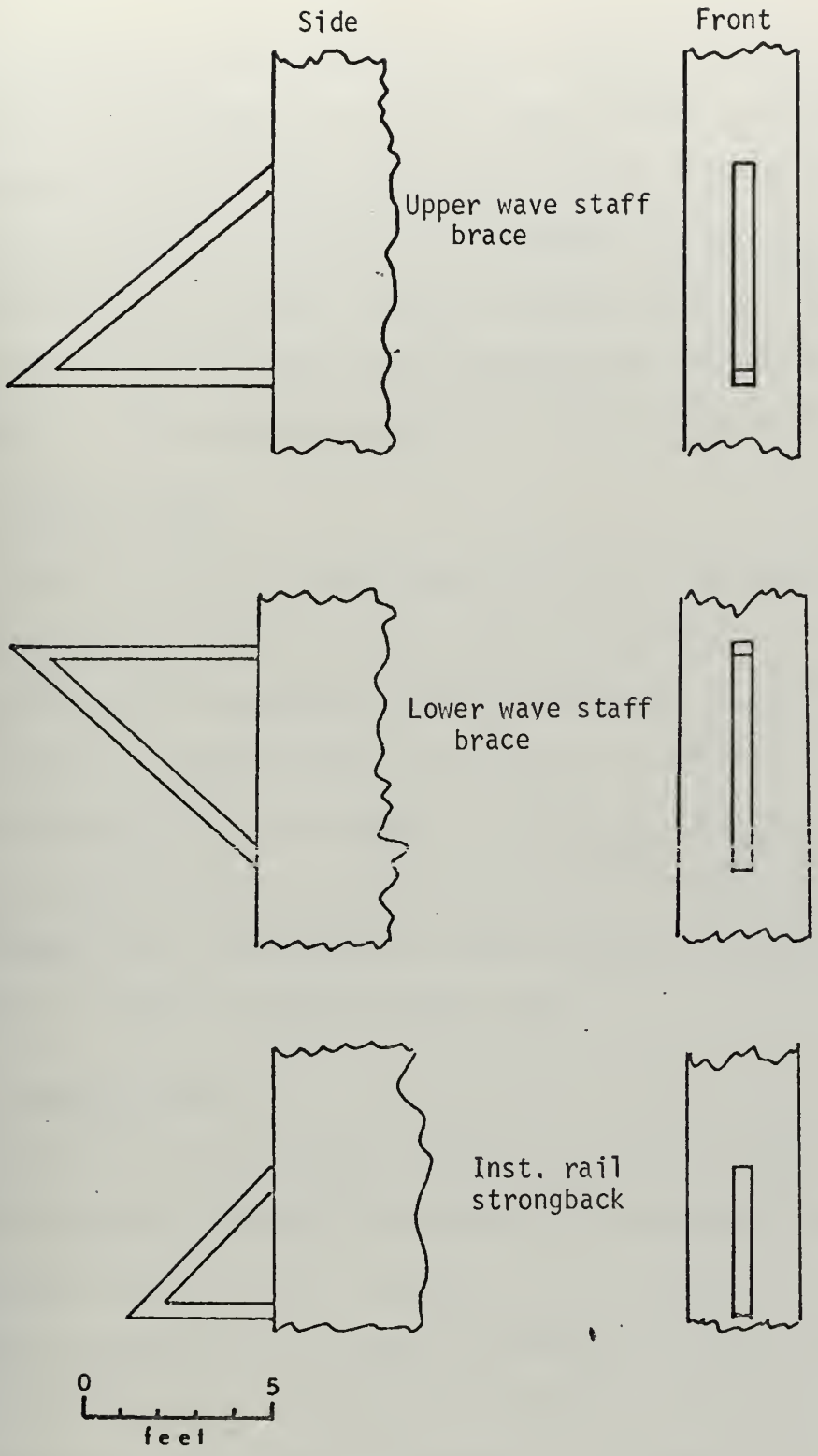


Figure 15. Upper and lower wave staff brace and instrument rail strongback.

These fittings will be attached at each available stanchion on the lower platform as indicated in Figure 14. These fittings are provided for researchers who need another boom from which to suspend sensors. The booms will have to be brought to the FLOSORP from the shore and attached to the fittings at the best location for each occasion. Each stanchion used for an auxiliary boom must be supported by a shroud to the main structure. The concept and details are shown in Figure 16.

G. UPPER PLATFORM

A five by five foot upper platform will be constructed on top of the main structure, thirty five feet above mean-sea-level. The frame for the platform will be made from 3.5 inch aluminum I-beams as illustrated in Figure 17. Expanded metal will be used as flooring. The handrails and stanchions will be made from two inch aluminum pipe. The function of the upper platform is to serve as an area from which to service the instrument mast, and navigational aids equipment and the telemetry antenna and other equipment mounted there.

H. INSTRUMENT MAST

An instrument mast, thirty feet long, will be erected on top of the main structure to increase the height above mean water level to which measurements can be made. The mast will be constructed from a light-weight aluminum pipe, six inches in diameter and reinforced by webbing on the inside and by shrouds on the outside. See Figure 17 for an illustration. Each shroud will require one spreader and a two foot brace extending out from the platform below. The spreaders can be constructed from aluminum pipe, or from hardwood. The mast will be equipped with studs along its entire length to allow personnel to climb up and to install or service sensors.

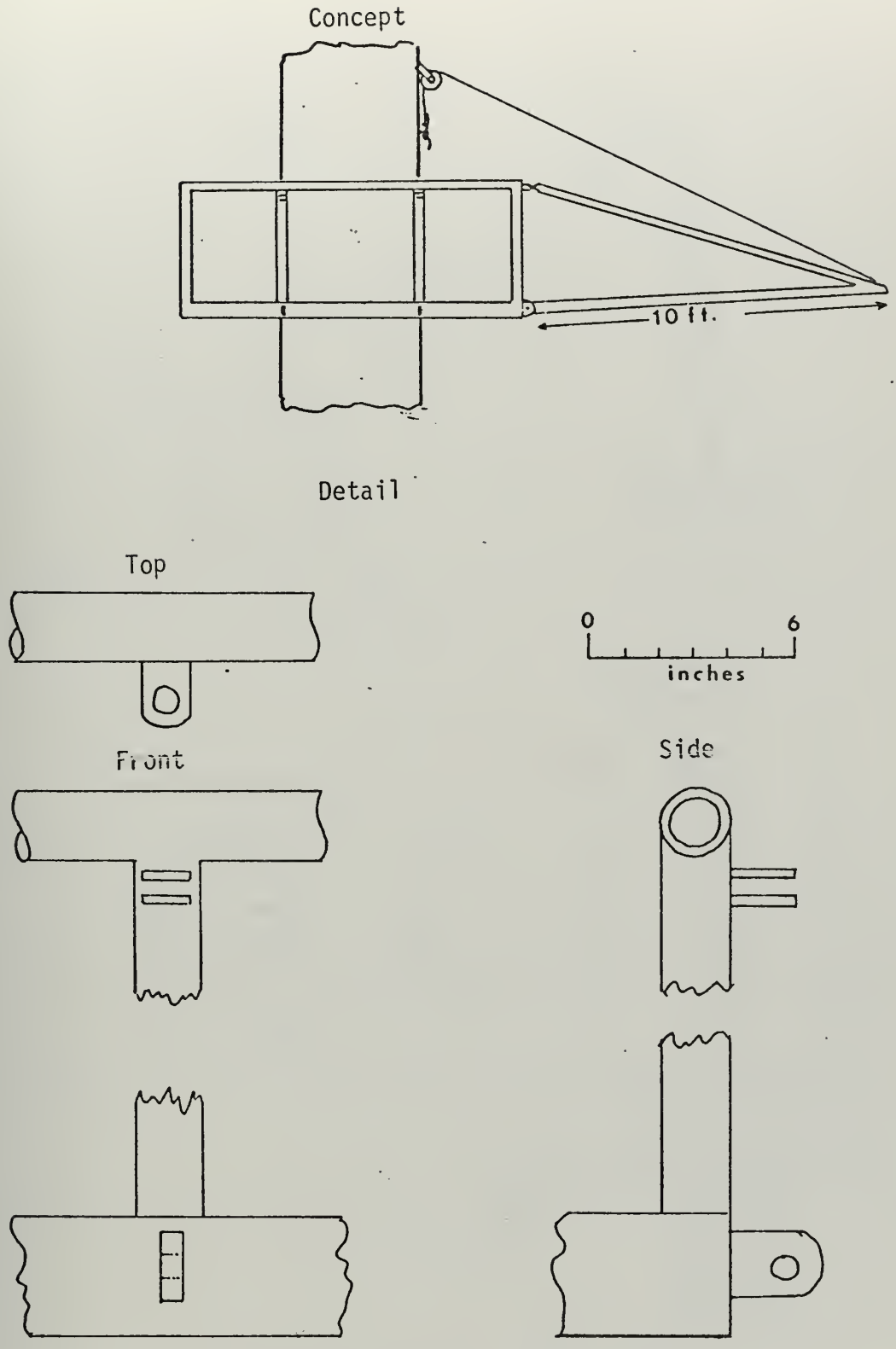


Figure 16. Concept and detail of portable boom attachment points.

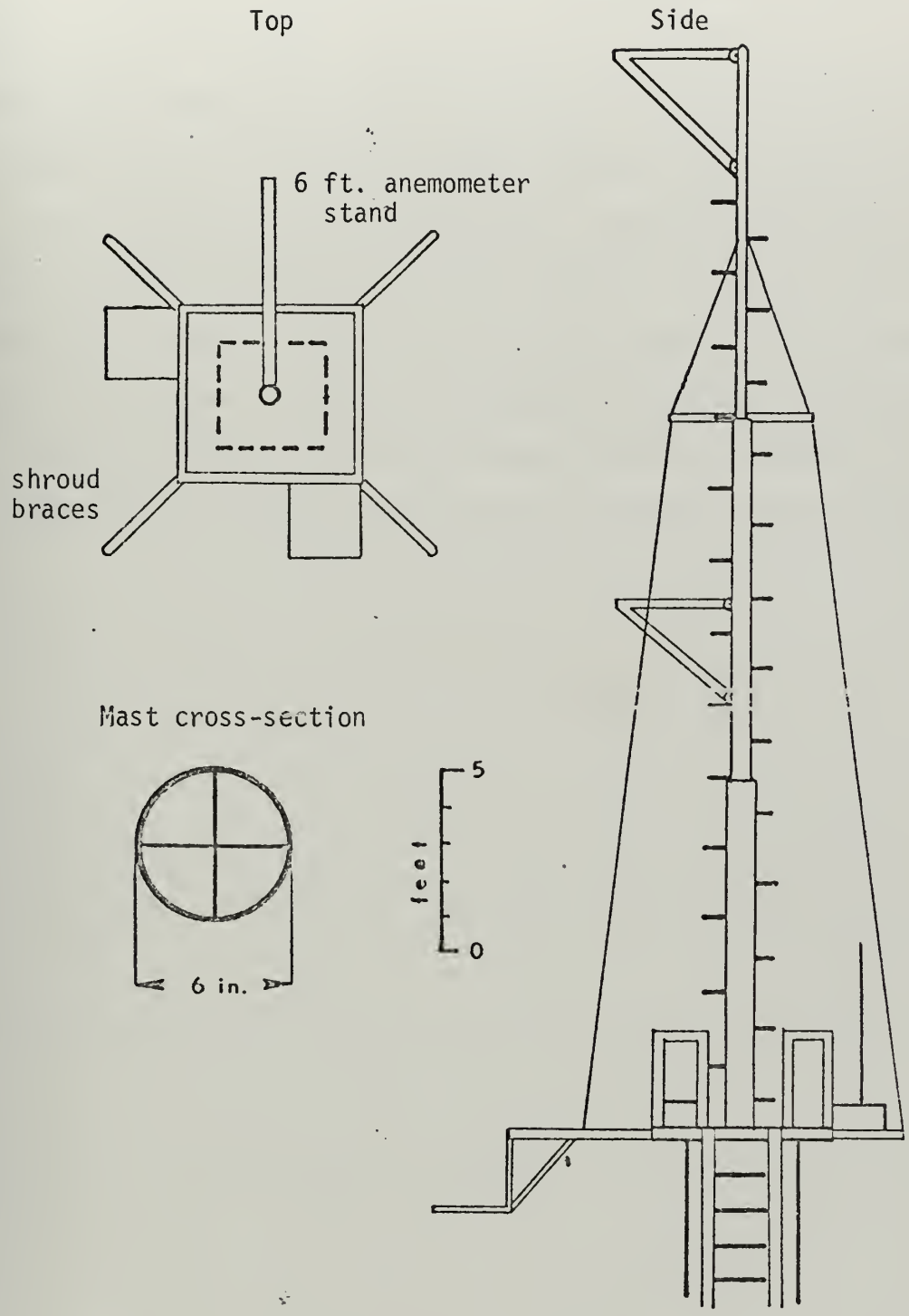


Figure 17. Upper platform including the 30 ft. instrument mast and a cross-section of the mast.

## I. INSTRUMENT SHELTER

The framework of the main structure from the lower platform to a height of eight feet above the platform will be enclosed by a light weight, weather proof bulkhead as shown in Figure 6. This area will serve as an instrument shelter. In the two landward sides of the bulkhead will be four access hatches to allow installation, servicing, calibration and removal of equipment records, and other electronics. On the interior side of the bulkheads, opposite to the access hatches, will be mounted braces for instrument shelving. The braces will have sufficient points for attaching shelving to allow for various sizes of equipment. Sufficient openings for cable penetration of the bulkhead will be installed.

## IV. PLATFORM ELECTRIC SYSTEM

The concept of installing a permanent power system on FLOSORP has been borrowed from the bottom mounted towers. The five year life span, and the expected diversity of experiments that will be conducted from the platform makes a constant and easy to use power source, that is readily available, highly desirable. Most sensors and recorders can be converted to operate on self contained battery power, but that would require more equipment space and would unnecessarily limit the type of instrument or equipment that can be used on FLOSORP.

The power sources feasible for FLOSORP are a shore power cable system, a motor generator set and a battery bank with a portable charger. More sophisticated systems such as fuel cells and nuclear generators were not considered due to expense. Each alternative has been considered and the shore power cable system has been chosen for reasons discussed below. Among the considerations were reliability, power system noise and interference with measurement, maintenance requirements, weight and power capabilities.

### A. MOTOR GENERATOR SET

A generator capable of delivering steady power sufficient for platform requirements has several undesirable characteristics. Its size and weight, although not significant when compared to the total FLOSORP, will take up much of the equipment space and total payload weight available. Even when shock mounted, a reciprocating engine will cause vibrations throughout the structure and noise in many of the measurements that will be taken. The environment on the bay is unfavorable for air breathing reciprocating

engines. Much more maintenance will be required to keep the generator operating than will be required at a shore installation where the environment can be controlled. The generator must be shut down while maintenance work is being accomplished on the engine and consequently those sensors and equipment requiring generator power must also be shut down. Fueling the motor generator system will be a difficult routine operation which cannot be undertaken while other operations on the platform are in progress. The govenor systems for motor generator sets will not endure the open ocean environment for extended periods. Much maintenance on this part of the system will also be required. Therefore the motor generator system, although a system worthy of consideration for shorter durations, is rejected as a choice for FLOSORP as a practical system for the five year period.

B. BATTERY POWER SYSTEM

A battery power system is the most inexpensive of the three systems considered. If cost is a prohibitive factor for the other systems and if utilization of A.C. powered sensors and recorders can be deferred, then the installation of a bank of batteries to power the FLOSORP's systems can be considered a solution. To reduce costs of batteries to a favorable level, ordinary car batteries purchased on the market must be utilized for this system. Batteries of this type weigh approximately 50 lb. each, and ten batteries will weigh 500 lb. To protect the batteries from sea surface spray they will have to be installed in a rack just below the upper platform. A concentration of this much weight at the upper extremity of the FLOSORP will be detrimental to the overall stability of FLOSORP. Recharging of batteries will interrupt the normal routine of data taking on the platform and will require much effort from

maintenance personnel. If batteries are run down they will not deliver rated power and could introduce errors into records of instruments taking continuous data.

C. SHORE POWER CABLE SYSTEM

The most flexible and useful power system for the FLOSORP is a shore power cable system from the commercial power system. Two disadvantages that this system has when compared to a motor generator or a battery system are the cost of a submarine cable and the actual laying of the cable. The first of these disadvantages can be met when such a cable is obtained from the government surplus system as has been possible in the past. The second, the laying of the cable, can be accomplished with the help of Navy personnel trained in such operations. The cable system then can become competitive with the other systems. Such a cable is presently in use on the NEL Tower in San Diego. It is a three conductor, number four wire lead coated armored submarine type cable. This cable is approximately one mile long and is rated at five kilo-volts. The transmission voltage is about 4000 volts. On the platform the voltage is reduced to 440 volts, 220 volts and 110 volts. The cable for FLOSORP will have to transmit voltage for approximately four nautical miles. The transmission voltage required for this distance is a higher voltage and will require a transformer on FLOSORP for voltage reduction to 110 volts. The cable will provide uninterrupted power to the platform to run sensors, recorders, and auxiliary equipment. The maintenance for such a power system will be negligible when compared to the other two systems discussed and therefore, is recommended as the best system for the FLOSORP.

## V. SENSOR SYSTEM

In this section a modest, yet diverse, initial set of permanently installed sensors for the FLOSORP will be proposed. The instruments described have been chosen on the basis of consultations with members of the faculty and oceanography technicians. Those instruments already on hand at the Postgraduate School have been chosen where possible. In choosing instruments not presently available at the school, only those incorporating the latest in the state-of-the-art are selected. As funds become availabe and as the state-of-the-art changes, old equipment can be replaced and new sensors added. Continuous readings of Meteorological, Oceanographic and Ocean Engineering parameters will serve as base line information for on going and projected research projects such as bay circulation, upwelling along the California Coast or salinity variations in Monterey Bay. All of the sensors will sample the parameters at predetermined times and durations to avoid excessive amounts of data.

### A. PLATFORM MOTION

A brief general summary of the effects of platform motion on sensor accuracy will be presented in this section. The motion of FLOSORP can be divided into four categories: heave, roll, surge and yaw. See Figure 18 for a representation of the motions. Roll and pitch are the same motion because of platform and mooring system symmetry. All the motions are distinct and can be readily recognized, however they are coupled and rarely occur alone.

The primary motion of FLOSORP will be a wave induced surging motion coupled with a roll about the center of motion and a slight heaving motion

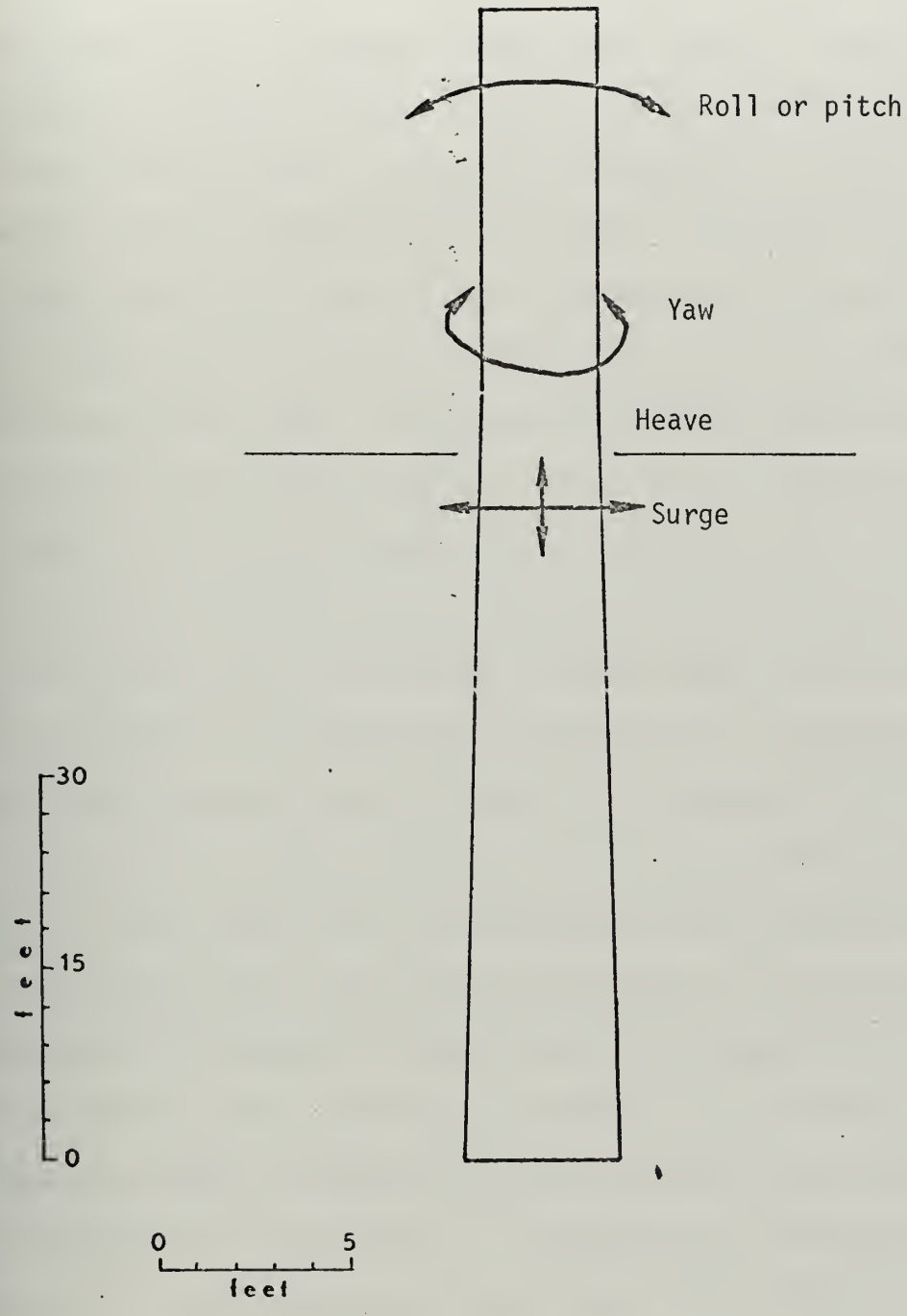


Figure 18. An illustration of FLOSORP motions.

due to the restraints of the anchor cables. The path of any point on the platform will describe an arc. The length of the path is a function of distance to the sensor from the center of rotation which will be at the point where the peripheral cables are attached to the platform. The motions will be oscillatory in nature with equal movement in both directions from equilibrium. The motion will show up on a data record as a series of peaks centered around the period, or frequency, of oscillation of the FLOSORP. The amount of error induced by the platform motion on the data records will depend on the frequencies of the parameter being measured by each sensor. Anemometers and current meters measure wind velocities over a broad spectrum. The period of oscillation of the FLOSORP is a very narrow band and will show up on these reading as peaks at the period of oscillation. Since oscillations are symmetric, they should average out to zero on any record. The effect of oscillatory platform motion on sensors such as thermistors or salinometers will be negligible because of the uniformity of the temperature and salinity fields in the horizontal plane over the distances that these sensors will move. Significant vertical displacement of these sensors could cause significant errors on the data record, however, the vertical motion of the platform associated with roll and heave is negligible thus making these errors small. The vertical movement of the sensors because the heave of FLOSORP is predicted to be on the order of one percent of the significant wave height, Ref. 7. Platform yaw is expected to be minimal because of the symmetric and equal forces on the platform from the mooring cables. A significant yaw, although oscillatory and symmetric, would appear on the wind direction data record and as a fluctuation in the current measurements.

A strong wind or current will also cause a mean tilt of the platform, affecting some of the sensors accuracies. The anemometers and current meters will be tilted with respect to the horizontal, therefore, they will not measure the true value of the current or wind. The sensors for gradient measurements will also be at different average heights above water level than their length along the vertical axis of the main structure. This change in height will put each sensor in a different part of the gradient, however, these excursions in the vertical will be very small and of no significance for most measurements.

The error induced by a mean platform tilt can be expressed by

$$V_m = V_t \times \cos \theta \qquad (1)$$

where $\theta$ is the mean tilt angle, $V_m$ and $V_t$ are the measured and true values respectively. From this relation one can derive the following expression for the error:

$$\text{error} = \frac{V_t - V_m}{V_t} \times 100 \qquad (2)$$

or from equation (1)

$$\text{error } (\%) = (1 - \cos \theta) \times 100 \qquad (3)$$

An analysis of the response of FLOSORP with a five point mooring system has been calculated by LCDR M. F. Crane, Ref. 7, using a theoretical fully developed wind generated wave spectrum described by Neumann in Ref. 8. The following table, taken from Crane's Thesis, shows calculations for significant heave, surge, pitch or roll, and total horizontal excursion at the main platform in response to the wave spectrum. Using equation (3) with the corresponding tilt angles from Table I, the associated errors are also given in Table I.

| $H_{1/3}$ (ft) | $X_{1/3}$ (ft) | $Z_{1/3}$ (ft) | $\theta_{1/3}$ degrees | Excursion (ft) | Sensor Error (%) |
|---|---|---|---|---|---|
| 1.3 | 0.36 | .024 | 0.78 | 0.98 | 0.00 |
| 3.7 | 1.78 | .066 | 2.00 | 3.37 | 0.0 |
| 7.7 | 4.8 | .119 | 6.33 | 9.82 | 0.9 |
| 13.5 | 6.37 | .177 | 8.51 | 13.12 | 1.4 |
| 21.3 | 7.65 | .232 | 10.47 | 15.94 | 1.6 |

TABLE I

Significant Heave, Surge, Pitch, and Excursion for Various Values of Significant Wave Height Using Five Point Mooring System.

B. METEOROLOGICAL SENSORS

The FLOSORP is an ideal platform from which to obtain wind and temperature profile data over exposed water from the surface to 65 feet above water level. The location of FLOSORP also makes it ideal for many other studies of the bay and for open water experiments.

1. Anemometers

Provisions have been made for a system of four anemometers to measure the mean wind speed profile. These anemometers will be mounted on the seaward side, 6 ft. out from the main structure at distances of 20, 32.8, 50 and 65 ft. above mean water level. The 6 ft. separation between the sensor and the main structure will give negligible interference from the platform in the wind measurements (Ref. 9). Only one anemometer at the 32.8 ft. (10 meters) mounting, will be in continuous operation. This elevation is the standard height for taking marine wind observations. The other three anemometers can be mounted when wind

profile measurements are desired. The anemometers are W101-P Skyvane I wind sensors, manufactured by Weather Measure Corporation of Sacramento, California. The signal from each anemometer will be fed into a W101-540° translator manufactured by the same corporation. The translator conditions the signal from the W101-P into data inputs for strip chart recorders, data logging and telemetry systems. The power requirements for the translator is 12 volt DC or 115 volts AC at 60 Hz. The translator and strip chart recorder will be mounted in the weather proof shelter.

The anemometers measure the mean wind in the horizontal plane. The platform motions discussed earlier will introduce false signals into the anemometer data record. The magnitude of the oscillatory contribution to the record can be illustrated by the following rather extreme example. For a five degree roll with a four second period, the RMS velocity of the anemometer, at 35 ft. above mean sea level, will be 8.7 ft/sec or 5.2 knots assuming that the center of rotation is at the base of the platform. This error is symmetrical, and therefore will average out to zero on the record. The contribution of the mean tilt angle to the wind data can be expressed by equation (3) in Section A. The wind data can be corrected to true wind speed by using the inclinometer measurements.

2. Thermistor Chain

To obtain a mean vertical temperature profile above the sea surface, a system of 12 thermistors will be mounted at five foot intervals from 10 to 65 feet above mean water level. The thermistors are TMT-I models manufactured by Weather Measure Corporation. The signal from the thermistors will be led to a T632T-12 temperature recorder. This recorder records all twelve sensor signals utilizing a dotting system with a different color ink for each sensor. The recorder switches input sensor

channels each 5 seconds and records the temperature. The recorder will be mounted in the weather proof shelter and requires 115 volt AC power.

The effect of FLOSORP motion on the thermistors will be negligible as indicated in Section A.

3. Pyranometer

In order to obtain continuous measurements of solar radiation a pyranometer will be mounted on the upper platform. The pyranometer will be connected to a strip chart, potentiometric recorder. Both the sensor and recorder are manufactured by Weather Measure Corporation. The recorder will be mounted in the upper part of the weather proof instrument shelter and will require 115 volt AC power. The pyranometer will be mounted on a stand on the upper platform.

The pyranometer measures direct and scattered solar radiation falling on a horizontal surface. The FLOSORP's motion will introduce an error into the solar radiation data record. The error is due to the difference of the sensor orientation from the vertical, because of both the rolling motion and the mean tilt of the platform. Since the pyranometer will always measure less radiation when disoriented from the vertical, the oscillatory motions will not average out as in the case for the anemometers. For example, the maximum error for the case where the roll is five degrees is less than 0.4 percent. The error associated with a mean tilt angle can be calculated by equation (3).

C. OCEANOGRAPHIC SENSORS

The location of the platform in Monterey Bay is suitable for studies of surface and internal waves, turbulence, salinity variations, currents and tidal levels. The monitoring of these parameters will be the purpose of the initial set of permanent oceanographic sensors on the FLOSORP.

1. Wave Gage

A wave recorder system will be installed on the seaward side of FLOSORP to measure waves and tides. The wave staff, manufactured by Baylor Company of Houston, Texas, is 53 ft. long and will be suspended between the two braces 6 ft. from the main structure, described in Section III(f)(4). The signal from the wave staff will be led to a recorder mounted in the shelter at the lower platform. The power requirement for the recorder system is 115 volts AC at 60 Hz and the sampling rate for data will be 20 min. in every four hours.

The predicted heave motion of the FLOSORP is less than one percentage of the wave height (Ref. 7). Since the accuracy of the wave staff is only within one percent of the length, 50 ft., the error introduced due to the heave motion of the platform is lost in the accuracy of the instrument. The effect of platform motion due to surge and roll on the wave measurements can be significant for the waves of periods less than approximately four seconds. For a rather extreme example, with a five degree roll over a four second period the total excursion at mean water level is 9.6 ft.. This would constitute an error of less than 12% for a four second wave having a deep water length of 82 ft.. The error would increase for smaller wave lengths. It is possible that certain wave frequencies will be completely masked by platform motion. By using the measurements of the accelerometers, however, the wave records may be corrected.

2. Thermistor System

In order to obtain a mean temperature profile of the water column on a continuous bases, a thermistor system consisting of three thermistors with 20 second time constants will be attached to the structure at 15 ft.

below mean sea level and suspended from the 10 ft. instrument boom at depths of 60 ft. and 120 ft.. The signal from the thermistors will be led to a read out unit which contains the power supplies to operate the thermistors and has provisions to connect an external recorder or digital read out. It is recommended that the thermistor chain be manufactured by Oceanography Department personnel and adapted to a three pen strip chart recorder. The effects of platform motion on the thermistor system will be negligible because the 20 second response time is too large to measure platform oscillations.

3. Current Meter

A remote reading, two orthogonal component, ducted current meter will be rigidly mounted on the ten foot underwater boom at a depth of 60 ft. This meter will measure the mean current for each component from which the resultant current speed and direction can be determined. The signals from the current meters will be sent to remote readout units and then to a two pen strip chart recorder in the instrument shelter.

The effect of platform motion on the current meters is similar to the effect on the anemometer. Each component current meter will be influenced by the oscillatory motion and the mean tilt. The oscillation will be small because the current meters will be located near the center of rotation and will average out to zero. The mean tilt correction can be calculated using equation (3).

4. Salinometer

A continuous record of salinity at the FLOSORP location will be very useful to researchers conducting circulation studies in Monterey Bay. The salinity reading at the platform can be used as a reference for, and tied in with, measurements taken in other parts of the Bay. A direct

reading salinometer (model 644) with a connection for a strip chart recorder is manufactured by Hydro-Products of San Diego, California. The instrument will be suspended from the 10 ft. underwater instrument boom and will require 12 volt DC power. The strip chart recorder will require 115 volts AC power.

The effect of platform motion on the accuracy of the salinometer readings will be negligible because of the very small salinity gradient over the distance that the sensor will move.

D. OCEAN ENGINEERING SENSORS

The FLOSORP provides an unique opportunity to observe and measure the response of a multi-point taut wire moored buoy of known mass and physical dimensions to a measured wave and wind environment. The following instruments will be installed to measure the platform response for the above purpose and to provide a means to correct for the platform motion on the other measured parameters.

1. Accelerometers

Three accelerometers will be mounted on the main structure at the upper platform. One instrument will be mounted to measure acceleration in each of the horizontal axis and the vertical axis. The signal from the accelerometers will be sent to a three pen strip chart recorder which will be mounted in the shelter at the lower platform.

2. Inclinometer

A two dimensional remote reading inclinometer with sufficient damping to filter out the oscillatory motions will be mounted on the upper platform. The output from the inclinometer will be led to a strip chart recorder in the shelter.

3. Compass

If it is found that the yaw motion is prominent, a magnetic compass will be mounted on the upper platform. The compass will send a signal to a recorder in the shelter at the lower platform. To calibrate the compass, bearings to known prominent objects on the shore must be taken, then converted to true and recorded. The same must be done with the relative orientation of the platform. The procedure must be repeated periodically to check compass drift or platform reorientation. The time interval must be determined from experience.

4. Tensiometers

At least two tensiometers to measure cable tension will be mounted on two of the peripheral anchor cables. These instruments will be remote reading with a recorder located in the shelter at the lower platform.

E. PROVISIONS FOR OTHER SENSORS

One of the primary purposes of this paper is to propose an initial set of permanently installed sensors on the FLOSORP. As discussed, the data from these sensors will be very useful for a wide range of interests. However, one of the greatest benefits that the FLOSORP will yield is that it will provide a platform in Monterey Bay from which a vast variety of short term, or long term experiments can be conducted. The primary limitation that researchers will find on the FLOSORP is space for their equipment.

The design of FLOSORP has incorporated provisions to maximize flexibility in the use of the platform. The rail and the pulley system from the 15 ft. instrument boom can be employed in air-sea interaction, acoustic

and optical studies and in other fields of interest. There are provisions to mount up to seven additional booms of varying length from the main platform. However, it is not anticipated that all of these booms will be used simultaneously.

## VI. DESCRIPTION OF MAIN STRUCTURE, MOORING SYSTEM AND UTILITY SYSTEMS

### A. MAIN STRUCTURE

The steel section of the present erector tower will be modified to provide sufficient buoyancy for the completed FLOSORP. The section of the tower, 5.5 feet to 45.5 feet from the base will be enclosed with 1/8 inch steel sheet metal welded to the structure. This compartment will be filled with 900 pounds of salvage foam buoyancy material. The total buoyancy of this chamber will be about 33,000 pounds. The weight of the completed platform will be 18,900 pounds. The aluminum section will be bolted to the steel section, however, the junction must be insulated and be given cathodic protection to prevent electrolysis of dissimilar metals.

The steel and aluminum sections must both be preserved prior to the deployment, but only after the major appurtenances have been attached to the main structure. Standard procedures should be used in sand blasting, priming, and painting. Preservation must be done properly because of the five year period when no underwater maintenance, other than scraping, can be accomplished.

### B. MOORING SYSTEM

A five point mooring system will be utilized to keep the FLOSORP stable and in position. This system has been chosen because it provides stability to a buoy with a relatively simple plan. If the stability of FLOSORP is not sufficient, then a more elaborate mooring system must be employed.

The major components of this system are four 700 ft. 1/2 inch plow steel cables, one 190 ft. one inch plow steel cable, four, 7 1/4 ton mooring anchors and one clump anchor weighing approximately 20 tons. The associated equipment for the mooring system includes four large diameter rollers, one tensioning winch and other small equipment such as shackles, wire guides, and securing gear for the cables.

The task of transporting the platform to its position and then mooring it will be performed by a U. S. Navy Salvage Ship from the Hunters Point Naval Shipyard. The platform will extend about 55 feet below mean sea level when in the erect position. The main one inch cable will be of a predetermined length and secure to the base of the platform and to the main anchor. The ship will lower the main anchor to the desired position, sinking the base of the platform. The four peripheral anchors must be accurately placed and then set before the lateral cables can be secured to the main structure. After the lateral cables have been led through the rollers and wire guides they can be attached to the tensioning winch for proper tensioning and securing. The exact location of the large diameter rollers on the structure and the exact tension in each wire are questions which are addressed by Lt. Crane's thesis.

## C. UTILITY SYSTEMS

To complete the platform several other features, which can be categorized under this heading, are proposed in this section.

### 1. Telemetry System

The author does not intend to design a telemetry system capable of serving the special needs of FLOSORP, however, the general criteria which such a system must meet are suggested. Reference 10, Volume IV,

contains an extended dissertation on the many aspects that must be considered when designing a telemetry system for a particular suit of sensors. The system for FLOSORP must be capable of handling not only the sensors proposed in this paper, but also other sensors which will be placed on the platform in the future. It must be compatible with the data processing equipment at NPS, now and in the future. Many corporations have propsed elaborate communication systems for the new Ocean Research building. Among these proposals is a RF transceiver for "fixed platforms." These systems, however, are not flexible enough for the FLOSORP. A study, by the title of PROJECT ODDS, was prepared by a group of Electrical Engineering students at NPS in 1969 (Ref. 11). ODDS stands for Oceanographic Data Delivery System. This study was a project to determine what oceanographic parameters can be monitored by electronic sensors and how to transmit and process the data. A similar kind of study should be undertaken and addressed specifically to the FLOSORP. The minimum weight and size requirement must be considered as a primary criteria in this study. An Electrical Engineering student could undertake, as a thesis objective, the design of a telemetry system for FLOSORP.

2. Radio Beacon Direction Finder

The probability of fog on Monterey Bay at the platform location is very high, necessitating the use of a direction finding system to vector the boat to the platform. The system consists of two major elements, one on the platform and one for boat use. Ocean Applied Research Corporation manufactures a system suitable for this purpose. The platform package consists of the BT-200-1 beacon Transmitter and an antenna. The boat unit is a Hand-held Receiver model FR-206-1. This unit will give bearing accuracy within five degrees.

3. Telephone

A submarine telephone cable will be led to FLOSORP from a terminal on shore. There is a need for a telephone on such a structure for several reasons. If the platform is involved in a coordinated study with a shore station, such communications are essential for coordination and information. If the boat cannot make a scheduled trip to the platform, personnel can be informed of such delays. Personnel on the platform need a means of communication with the shore in case of emergencies.

4. Electric Utility Winch

A small, light weight winch with a 200 pound working capacity will be required to perform loading and unloading operations, hydrocasts and MBT casts. To be able to do all these functions, the winch must have the capability to pay out wire either by free wheeling or under motor control.

5. Water Pump

The FLOSORP will require a pump capable of providing salt water at the lower and upper platform for safety and sanitary reasons.

6. Navigational Aids

The navigational aids package will be determined by the U. S. Coast Guard after formal permission has been granted by the U. S. Army Corps of Engineers to put the FLOSORP at the proposed site.

7. Miscellaneous

Items such as chemical and $CO_2$ fire extinguishers, life rings, first aid kit, emergency rations and distress signals must be provided on the FLOSORP. Although these items are highly pilferable, they must be maintained on the platform for safety reasons. Other items such as tools should be carried back and forth by the technicians and researchers.

## VII. CONCLUSIONS

It was the purpose of this study to determine the most suitable location for a floating stable oceanographic research platform, in Monterey Bay, to determine the design of the structure, to propose a power system for the structure, and to propose an initial set of sensors for the platform and the effects of buoy motion on the data from these sensors. The following conclusions apply to these objectives.

1. The most suitable location for the FLOSORP is at 36° 43.95'N and 121° 52.65'W because this is the best compromise from scientific and practical considerations.

2. In order to keep the weight of the platform at a minimum and to afford the maximum flexibility, the following major appurtenances should be mounted on the platform:

   (a) a boat fender for boat operations,

   (b) a ladder for accessibility to the under water structure,

   (c) two underwater booms for mounting sensors and blocks,

   (d) a rail and instrument cart system for controlled depth experiments,

   (e) a 9 by 9 ft. working platform 18 ft. above mean sea level on which should be mounted a 15 ft. instrument boom, a 10 ft. utility boom, and from which most sensors will be controlled,

   (f) a five feet square working platform 35 ft. above mean sea level,

   (g) a 30 ft. instrument mast on top of the main structure for air temperature and wind profile measurements,

   (h) other fixtures such as wave staff braces, a pulley strongback and an instrument shelter should also be mounted on the main structure.

3. Because of the minimum of a five year service life of the FLOSORP, a submarine cable power system should be installed to provide electricity for sensors, recorders, and utility systems.

4. In order to measure the basic parameters in Oceanography, Meteorology and Ocean Engineering, the initial suit of sensors should include an anemometer and thermistor system for wind and air temperature profile measurements, a pyranometer for solar radiation measurements, a wave staff for wave and tide measurements, a salinometer for salinity measurements, a thermistor chain for water column temperature profile and internal wave studies, accelerometers and inclinometers to record platform motion and tensiometers to measure cable strain.

5. The platform motion will affect the data from some sensors, however, this effect can be corrected by correlation with the buoy motion records from the accelerometers and inclinometers.

The FLOSORP is designed to sustain the environment in Monterey Bay for a minimum expected life of five years without maintenance other than periodic replacement of zinks used for cathodic protection. The environmental design criteria, considered to be reasonable expectations for Monterey Bay for the five year period are a significant wave height of 21.3 ft., a steady wind of 30 kts. and a mean current of one knot.

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ABSTRACT

The Naval Postgraduate School plans to erect a floating stable oceanographic research platform in 240 ft. of water in Monterey Bay during the spring of 1972. The platform will utilize a multi-point mooring system and will have a minimum of five tons reserve buoyancy and a total weight of 11 tons. The criteria for selecting an optimum location for the platform are discussed and a selection is made based on a compromise of the various considerations. It is concluded that the best source of power should be a submarine cable from the shore because of the five year minimum life expectancy of the platform. The initial set of permanently installed sensors should include instruments to measure basic parameters in the areas of Meteorology, Oceanography and Ocean Engineering. These include wind, air temperature, solar radiation, waves, tides, water temperature, salinity, currents, platform motion, platform tilt and cable tension. In order to provide a maximum variation of platform use, and to keep the weight of the platform a minimum, appurtenances including instrument booms above and below water, a rail and instrument cart system for profiling over depths, two working platforms and a 30 ft. instrument mast are described.

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